Forum Reply

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Peneplain formation in southern Tibet predates the India-Asia collision and plateau uplift

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Tian et al. (2013) challenge our interpretation that peneplain formation in the Lhasa terrane occurred prior to plateau uplift, when the region was still at low elevation and externally drained. Instead, they suggest an internal drainage at high elevation already in the late Cretaceous–Paleogene. As the timing of plateau uplift is crucial for understanding the evolution of Tibet, we thank Tian et al. for the opportunity to elaborate on these conflicting interpretations.

We first address the question of how much shortening occurred in the Lhasa terrane prior to ca. 50 Ma. A close inspection of the study by Kapp et al. (2007a), who inferred >230 km of shortening in the southern Lhasa terrane between ca. 90 and 53 Ma, raises severe doubts on this huge amount of shortening, because it is based on the restoration of a cross section constructed from a simplified geological map and the postulation of two detachments. The restoration implies >150 km of slip on the hypothetical upper detachment, with almost no hanging wall deformation (Kapp et al., 2007a). We regard this scenario as very unlikely and argue that the surface geology can be explained with considerably less shortening. Moreover, the northern margin of the thrust belt does not extend into the studied peneplain region but ends farther south. Whether deformation did propagate to the peneplain area is an open question. A second study cited by Tian et al. describes the development of a thrust belt in the Nima area (northern Lhasa terrane) during the accretion of the Lhasa block to Asia (Kapp et al., 2007b). The reported total shortening since the Early Cretaceous is >58 km, but this value includes a post-Eocene shortening of >25 km (Kapp et al., 2007b), which reduces the early-middle Cretaceous shortening to >33 km. We stress that the age of shortening given as "ca. 100–50 Ma" by Tian et al. is incorrect. Instead, Kapp et al. (2007b) infer an age of ca. 125 to ca. 95 Ma and write: "Geologic relations provide no evidence for significant deformation in the Nima area subsequent to Cenomanian time and prior to the onset of non-marine sedimentation during the late Oligocene" (p. 927–928). The ca. 50 Ma depositional hiatus mentioned by Tian et al. does not necessarily imply shortening. It may simply reflect isostatic uplift during long-lasting erosion of the mountains created along the Bangong suture in the early-middle Cretaceous. Furthermore, shortening in the Lhasa terrane may have varied significantly along strike. For example, Kapp et al. (2005) estimated that Cretaceous shortening declines from 150 km (at 84°E) to 70 km in the Nima area (at 87°E). In the peneplain region, ~250 km farther east at 90°E, shortening may be even less. Hence, extrapolating geological data from 2-D profiles over hundreds of kilometers along strike into three dimensions—as done by Tian et al. in their figure 1B, which shows east-west mountain ranges acting as barriers for sediment transport at infinity—is speculative and not supported by data.

The other points raised by Tian et al. are related to the paleogeography inferred from provenance studies and the question whether the northern Lhasa terrane was *internally* or *externally* drained during late Cretaceous–Paleogene time. Our thermochronologic data indicate the removal of 3–6 km of rock between ca. 65 and ca. 50 Ma (Hetzel et al., 2011). Given the vast extent of the peneplain (150 × 75 km), we consider the proposition of Tian et al. that the material was "deposited locally in terrestrial basins within the northern Lhasa terrane" as unreasonable. If—in the Paleocene—an internal drainage had already existed, the Lhasa terrane would have been largely covered by sediments from the eroding mountains farther north and south—similar to what is happening in the Qaidam Basin since the Pliocene (Métivier et al., 1998). Tian et al. argue that the provenance of sediments in basins adjacent to the Gangdese arc (e.g., Liuqu, Xigaze, and Takena Formations) indicates an internal drainage of the northern Lhasa terrane. The Liuqu Formation consists of coarse clastic deposits with rapid lateral facies changes that accumulated in relatively small elongated oblique-slip basins (Davis et al., 2002). Such basins typically receive detritus from local sources and are therefore not very informative with respect to large-scale drainage systems. However, although provenance and detrital zircon data indicate mainly local sources for the Liuqu Formation, it is evident that a minor contribution may in fact be derived from the northern Lhasa terrane (see Wang et al., 2010, their figure 5). Likewise, zircon U-Pb and Hf isotopic data show that the Early Cretaceous granitoids of the northern Lhasa terrane may also be one of the sources for the Xigaze flysch (Wu et al., 2010). Thus, a *complete* absence of material from the northern Lhasa terrane—as required for the internal-drainage hypothesis—is incompatible with the available data. The presence of fluvial sediments in the foreland basin north of the Gangdese arc (i.e., Lhunzhub Member of the Takena Formation) is also insufficient to prove an internal drainage. As evident from the Hexi corridor—the presently active foreland basin of the Qilian Shan (Métivier et al., 1998)—major rivers may still leave such basins. Based on these considerations, we retain our interpretation that the peneplain region was *not* internally drained. The rivers that left the area may have formed direct, though widely spaced, gateways across the Gangdese arc to the Neotethys, or alternatively may have flowed from the Lhasa terrane eastward before delivering their sediment to the Bengal Basin (cf. Najman et al., 2008). Even a northward drainage to the Hoh Xil and Tarim basins is possible (cf. Bosboom et al., 2011; Dai et al., 2012).

Finally, we would like to highlight that the lack of evidence for tectonic denudation requires the erosive exhumation of the study area to explain our thermochronologic data. This, in turn, requires high precipitation and run-off, which is supported by the paleo-position of Eocene "Tibet" at tropical to subtropical latitudes (Lippert et al., 2011). Internal drainage of such a huge system at high elevation would require long-lasting effective barriers on all sides of the eroded, and finally planated, region, despite the coeval existence of basins at or near sea level farther south and north. Thus, we consider the scenario suggested by Tian et al. is highly unlikely.

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REFERENCES CITED

Bosboom, R.E., Dupont-Nivet, G., Houben, A.J.P., Brinkhuis, H., Villa, G., Mandic, O., Stoica, M., Zachariasse, W.J., Guo, Z., Li, C., and Krijgsman, W., 2011, Late Eocene sea retreat from the Tarim Basin (west China) and concomitant Asian paleoenvironmental change: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 299, p. 385–398, doi:10.1016/j.palaeo.2010.11.019.

Dai, J., Zhao, X., Wang, C., Zhu, L., Li, Y., and Finn, D., 2012, The vast proto-Tibetan Plateau: New constraints from Paleogene Hoh Xil Basin: Gondwana Research, v. 22, p. 434–446, doi:10.1016/j.gr.2011.08.019.

Davis, A.M., Aitchison, J.C., Badengzhu, Luo, H., and Zyabrev, S., 2002, Paleogene island arc collision-related conglomerates, Yarlung-Tsangpo suture zone, Tibet: Sedimentary Geology, v. 150, p. 247–273, doi:10.1016/S0037-0738(01)00199-3.

Hetzel, R., Dunkl, I., Haider, V., Strobl, M., von Eynatten, H., Ding, L., and Frei, D., 2011, Peneplain formation in southern Tibet predates the India-Asia collision and plateau uplift: Geology, v. 39, p. 983–986, doi:10.1130/G32069.1.

Kapp, P., Yin, A., Harrison, T.M., and Ding, L., 2005, Cretaceous-Tertiary shortening, basin development, and volcanism in central Tibet: Geological Society of America Bulletin, v. 117, p. 865–878, doi:10.1130/B25595.1.

Kapp, P., DeCelles, P.G., Leier, A.L., Fabijanic, J.M., He, S., Pullen, A., Gehrels, G.E., and Ding, L., 2007a, The Gangdese retroarc thrust belt revealed: GSA Today, v. 17, no. 7, p. 4–9, doi:10.1130/GSAT01707A.1.

Kapp, P., DeCelles, P.G., Gehrels, G.E., Heizler, M., and Ding, L., 2007b, Geological records of the Lhasa-Qiangtang and Indo-Asian collisions in the Nima area of central Tibet: Geological Society of America Bulletin, v. 119, p. 917–933, doi:10.1130/B26033.1.

Lippert, P.C., Zhao, X., Coe, R.S., and Lo, C.-H., 2011, Palaeomagnetism and $^{40}Ar/^{39}Ar$ geochronology of upper Palaeogene volcanic rocks from Central Tibet: Implications for the Central Asia inclination anomaly, the palaeolatitude of Tibet and post-50 Ma shortening within Asia: Geophysical Journal International, v. 184, p. 131–161, doi:10.1111/j.1365-246X.2010.04833.x.

Métivier, F., Gaudemer, Y., Tapponnier, P., and Meyer, B., 1998, Northeastward growth of the Tibet plateau deduced from balanced reconstruction of two depositional areas: The Quaidam and Hexi Corridor basins, China: Tectonics, v. 17, p. 823–842, doi:10.1029/98TC02764.

Najman, Y., and 15 others, 2008, The Paleogene record of Himalayan erosion: Bengal Basin, Bangladesh: Earth and Planetary Science Letters, v. 273, p. 1–14, doi:10.1016/j.epsl.2008.04.028.

Tian, Y., Kohn, B.P., Gleadow, A.J.W., and Hu, S., 2013, Peneplain formation in southern Tibet predates the India-Asia collision and plateau uplift: Comment: Geology, e295, doi:10.1130/G33617C.1.

Wang, J.-G., Hu, X.-M., Wu, F.-Y., and Jansa, L., 2010, Provenance of the Liuqu Conglomerate in southern Tibet: A Paleogene erosional record of the Himalayan-Tibetan orogen: Sedimentary Geology, v. 231, p. 74–84, doi:10.1016/j.sedgeo.2010.09.004.

Wu, F.-Y., Ji, W.-Q., Liu, C.-Z., and Chung, S.-L., 2010, Detrital zircon U–Pb and Hf isotopic data from the Xigaze fore-arc basin: Constraints on Transhimalayan magmatic evolution in southern Tibet: Chemical Geology, v. 271, p. 13–25, doi:10.1016/j.chemgeo.2009.12.007.